BLOOD-CELL COUNTING:

A SERIES OF OBSERVATIONS WITH THE HÉMATIMÈTRE OF MM. HAYEM AND NACHET, AND THE HÆMACYTOMETER OF DR. GOWERS.

BY

FREDERICK P. HENRY, M. D.,
PHYSICIAN TO THE HOSPITAL OF THE PROTESTANT EPISCOPAL CHURCH, PHILADELPHIA,

AND

CHARLES B. NANCREDE, M. D.,
SURGEON TO THE HOSPITAL OF THE PROTESTANT EPISCOPAL CHURCH, PHILADELPHIA, AND LECTURER ON THE DESCRIPTIVE ANATOMY OF THE BONES AND JOINTS, IN THE UNIVERSITY OF PENNSYLVANIA.

[Reprinted from The Boston Medical and Surgical Journal, 1879.]

CAMBRIDGE:
Printed at the Riverside Press.
1879.

BLOOD-CELL COUNTING:

A SERIES OF OBSERVATIONS WITH THE HÉMATIMÈTRE OF MM. HAYEM AND NACHET, AND THE HÆMACYTOMETER OF DR. GOWERS.

BY FREDERICK P. HENRY, M. D.,

Physician to the Hospital of the Protestant Episcopal Church, Philadelphia,

AND CHAS. B. NANCREDE, M. D.,

Surgeon to the Hospital of the Protestant Episcopal Church, and Lecturer on the Descriptive Anatomy of the Bones and Joints in the University of Pennsylvania.

VARIOUS instruments have been devised for a more accurate diagnosis of blood diseases than can be made by a mere observation of the symptoms of these affections. Such symptoms are all secondary, and are mostly due to imperfect nutrition of the nervous and muscular systems, imperfect oxidation, and vitiated secretion. In different cases one set of symptoms may be so prominent as to obscure all the others, and in any case symptoms due to a local affection may be confounded with those due to a general blood disease. In many cases nothing but a numeration of the blood cells can even determine the existence of an anæmia, and perhaps in no case can any other method distinguish its precise variety.

The instruments used for this purpose are all constructed upon the same principle, the different modifications being such as are designed to facilitate the rapid counting of the cells, and the easy reckoning of their percentage as compared with the standard of health. A known quantity of blood is diluted with a known quantity of fluid, and in a cell of a certain depth and superficies — the latter determined by squares of a certain size ruled upon the eye-piece of the microscope, or on the bottom of the cell containing the blood — the number of corpuscles is counted. With these factors, — the depth of the cell, its superficies, and the amount of the dilution, — the number of corpuscles in a cubic millimetre of blood is readily estimated. It is self-evident that the more the blood is diluted, the easier is the counting of the corpuscles, and the longer the subsequent calculation.

The most recent of these modified instruments is that of Dr. Gowers, of London. The following description of the instrument and its use is

taken from an article by Dr. Gowers in the *Lancet* for December 1, 1877: —

"The hæmacytometer consists of (1) a small pipette, which, when filled to the mark on its stem, holds exactly 995 cubic millimetres. It is furnished with an india-rubber tube and mouth-piece to facilitate filling and emptying. (2.) A capillary tube marked to contain exactly five cubic millimetres, with india-rubber tube for filling, etc. (3.) A small glass jar in which the dilution is made. (4.) A glass stirrer for mixing the blood and solution in the glass jar. (5.) A brass stage plate carrying a glass slip, on which is a cell, one fifth millimetre deep. The bottom of this is divided into one-tenth-millimetre squares. Upon the top of the cell rests the cover glass, which is kept in its place by the pressure of two springs proceeding from the ends of the stage plate. . . .

"The mode of proceeding is extremely simple. Nine hundred and ninety-five cubic millimetres of the solution are placed in the mixing jar; five cubic millimetres of blood are drawn into the capillary tube from a puncture in the finger, and then blown into the solution. The two fluids are well mixed by rotating the stirrer between the thumb and finger, and a small drop of this solution is placed in the centre of the cell, the covering glass gently put upon the cell and secured by the two springs, and the plate placed upon the stage of the microscope. The lens is then focused for the squares. In a few minutes the corpuscles have sunk to the bottom of the cell, and are seen at rest on the squares. The number in ten squares is then counted, and this multiplied by ten thousand gives the number in a cubic millimetre of blood.

"The average of healthy blood was decided by Vierordt and Welcker to be five million per cubic millimetre, and later results agree with this sufficiently nearly to justify the adoption of this number as the standard, it being remembered that in a healthy adult man the number may be a little higher, in a woman a little lower. The number per cubic millimetre is the common mode of stating the corpuscular richness of the blood, but by employing this dilution and squares of this size a much more convenient mode of statement is obtained. Taking five million as the average per cubic millimetre for healthy blood, the average number in two squares of the cell is one hundred. These two squares contain .00002 cubic millimetre of blood, and it is proposed to take this quantity as the 'hæmic unit.' The number per hæmic unit, that is, in two squares (ascertained by counting a larger number, ten or twenty, and taking the mean), thus expresses the percentage proportion of the corpuscles to that of health, or, made into a two-place decimal, the proportion which the corpuscular richness of the blood examined bears to healthy blood taken as unity. This is a much more simple method than any hitherto used. The proportion of white corpuscles to the red, or their number per hæmic unit, is best ascertained by observ-

ing the number of squares visible in the field of the microscope, and noting the number of white corpuscles in a series of ten or twenty fields. The number of red corpuscles corresponding to the ten or twenty fields is easily computed, and thus the proportion of white to red is ascertained. The normal *maximum* of white per two squares (hæmic unit) is three."

We each obtained one of these hæmacytometers at about the same time, and, with the object of testing the instruments, began a series of observations upon our own blood, preliminary to a proposed series of observations as to the effect of certain drugs. We soon discovered that the two instruments behaved very differently. Suspicion was first aroused in the following manner: One of us had examined the blood of a hospital patient suffering with intermittent fever, who had been selected for experiment on account of his sallow and anæmic appearance, and the absence of any perceptible enlargement or disease of spleen, liver, or any of the hæmopoietic organs. It was a case in which the results of appropriate treatment would probably be speedily manifested, and especially through an increase of the red blood cells.

The first count was made on October 3d, at 12.30 P. M. Ten squares were counted with the following result: number of red cells per c. mm., 3,420,000; percentage proportion to healthy blood, $68\frac{4}{10}$; number of white cells in the ten squares, seven.

The second count was made on October 7th, and this time twenty squares were counted: number of red cells per c. mm., 2,675,000; percentage proportion to healthy blood, $53\frac{1}{2}$; number of white cells counted in the twenty fields, two.

As the man had had no return of the ague since September 30th, and had improved in strength to such an extent that he was anxious to leave the hospital and return to his occupation, this result very naturally caused considerable astonishment. The care taken to prevent error in manipulation was so great that it was impossible to attribute it to that source. It was very soon ascertained, however, that the cell used at this examination was not the same as at the first observation.

In working together we had, unintentionally, exchanged cells. On October 15th we took the two cells to Mr. Zentmayer, and had them measured. It was then ascertained that there was a difference in depth between the two of $\frac{1}{400}$ inch, the shallower one having been used at the latter of the two observations just referred to.

One cell measured $\frac{5}{800}$ inch deep, the other $\frac{7}{800}$ inch. The cells ought to be $\frac{1}{5}$ millimetre deep, or, taking the millimetre as $\frac{1}{25}$ inch, $\frac{1}{125}$ inch. Neither of them, therefore, was accurate, one being $\frac{1}{160}$ inch deep, the other about $\frac{1}{114}$. The next thing to be done was to determine, by a series of observations, to what extent the results obtained by the two cells varied. Mathematically, they were to each other as five to seven; that

is, there should be between them a difference of forty per cent. In counts of the same blood, made with the two instruments, that is, of diluted blood taken from the mixer at the same time, no such difference of results was ever observed, the utmost variation being eighteen per cent., the least $11\frac{4}{10}$ per cent., the average $14\frac{7}{10}$ per cent. Our experience goes to show that undue importance has been attached to the depth of the cell in these instruments. There are other factors in the calculation of so much greater importance as to cause this one to assume a decidedly subordinate position. These sources of error may be inferred when we come to state the precautions we have taken to avoid them. Suffice it to say here that the effect of gravity upon the blood corpuscles is the same in cells of all depths. In Dr. Keyes's article on Mercury in the Treatment of Syphilis, which was originally published in January, 1876,[1] he remarks that for "accurateness of results the glass cells must be absolutely equal in depth. . . . There is a difference of about $\frac{1}{50}$ millimetre between my cell and one in the possession of Dr. Stimson. There is a uniform difference of about ten per cent. in the count of the same blood in the different cells."

This difference, ten per cent., is exactly what one would expect to find, *a priori*, mathematically. After our cells were measured we expected to find, upon mathematical grounds, a difference between them of forty per cent., and suffered about twenty-five per cent. of disappointment. The only explanation of these discrepancies that we would suggest is that, *up to a certain point*, the depth of the cell has a direct and regular influence upon the result; beyond this point, the depth of the cell is a matter of minor consideration. If the cell were *filled* with blood, the depth would always affect the result, but this is never the case; a drop of diluted blood is deposited upon the slide, the glass cover laid upon the drop, with its edges resting upon ground glass to prevent evaporation; the moment the diluted drop is placed upon the slide its contained corpuscles begin to gravitate with great rapidity, and as the drop is generally of nearly uniform size, and as, whether larger or smaller, it rises to the same height above the level of the glass, the depth of the cell can only determine the amount of pressure made by the cover glass upon the liquid; the deeper the cell the less the pressure, and *vice versa*. The corpuscles have, through gravity, a tendency to assume a certain arrangement, which tendency is not to be overcome, but merely interfered with, by pressure from any direction. Of two cells holding a drop of diluted blood, in the deeper the pressure of the cover glass will exert the least influence, and will be directly applied to a layer of fluid containing comparatively few corpuscles, perhaps none whatever. The effect of this pressure is chiefly to spread this clearer stratum of fluid over the corpuscles, and not to deflect these from their perpendicular descent. Our statement that up to a certain

[1] Am. Jour. Med. Sci.

point the varying depth of the cells influences the number of corpuscles in the field, while beyond this point the depth exerts no appreciable influence is, as we have endeavored to show, founded upon correct principles. The undue importance ascribed to the depth of the cell by many observers arises, we think from the fact that they have not constantly borne in mind that they were not dealing with a homogeneous fluid.

In order to estimate the value of blood-cell counting as a method of diagnosis and a guide to therapeutics, we have preserved records of sixty-three counts, thirty-five of these with Gowers's hæmacytometer, the remainder with that of Hayem and Nachet. The counts may be divided into two series: in the first series no particular attention was paid to the cover glass used, one being, at each observation, selected at random from a number that accompanied the instruments. Having found a great variation in the different observations, and with the object of making the conditions of each count identical, a cover glass was selected as free from blemish as possible, and the same side was always applied to the fluid. This was accomplished by marking the side that was kept uppermost, and this mark was invariably placed in the same position. Finally, to insure still greater accuracy, one of us had a cover glass *ground* by Mr. Zentmayer, and this glass was also used with the same precautions. It is unnecessary to dilate upon the importance of using the same cover glass in the same position. All practical microscopists are well acquainted with the flaws and curves of these glasses, and it will be at once conceded that if, in such extremely delicate work as blood-cell counting, at one observation the convex side of a glass be applied to the blood, and at another time the concave side, the discrepancies resulting therefrom may be very great.

When all is told, however, the great source of inaccuracy is in the *measurement* of the blood and the diluting fluid. By counting a great number of squares any inequality in the distribution of the corpuscles may be compensated for to a great extent, but in two successive measurements and counts of the same blood we have found an extreme variation of 790,000 per c. mm. The observations giving this extreme variation were made in rapid succession, and the measurements corroborated by both of us; they appeared absolutely correct in both instances. One result of our observations, therefore, is that no one measurement of blood can be relied upon as trustworthy, no matter how great a number of squares be counted, but that at least two should be made, more if possible, especially if any therapeutic inductions are to be drawn from the facts observed. Keyes has found a difference of two hundred thousand to the c. mm. in different parts of the same field, and we, in double the number of *physiological* counts recorded in his paper, have observed still wider variations; and when to this source of error arising from irregular distribution is added the vastly greater one arising from the measurements, no matter how carefully made, it will at once be

perceived that a difference of five hundred thousand to the c. mm. is by no means a great one. If this difference should happen to be in the direction of excess while the patient is taking a certain drug, the increase is naturally attributed to the medicine, and *vice versa.* Again, we repeat that averages both of counts and measurements, but especially of the latter, are absolutely necessary in order even to approach an accurate result. A single measurement, with a count of five, ten, or twenty squares, we consider almost worthless. Its sole value consists in that it contributes to form an average.

Although our observations were made with the view of testing the accuracy of the instruments employed in blood-cell counting, yet, as they were physiological, neither of us having had a day's sickness since they were begun, they possess a certain value for determining the normal number of red cells per millimetre. This is variously stated by authors. Vierordt, the first worker in this field, whose method was very uncertain, consisting in spreading blood diluted with a gummy solution upon a slide, allowing it to dry, and then counting the cells by means of a micrometer placed directly upon it, gives the number for his own blood as 5,174,000; Welcker states it for himself as 4,600,000; Cramer as 4,726,000; and Malassez indicates 4,000,000 as the average of the blood of man. Gowers adopts a standard of 5,000,000, but states that "in a healthy adult man the number may be a little higher, in a woman a little lower." Keyes thinks the standard of 5,000,000 rather high. We, on the contrary, have found it too low. For one of us, the average of twenty-one counts gives 5,566,272.5; for the other, twenty-six counts give an average of 5,935,862.5, the difference seeming to depend upon weight and size. That the number given by Malassez is absurdly low is presumptively proved by the following facts. In the *Gazette hebdomadaire* for May 7, 1875, is the report of a lecture on blood-cell counting by M. Hayem, which, besides containing an excellent short bibliographical *résumé* of the subject, gives the report of a case of a profoundly anæmic individual suffering with malarial cachexia and gangrene of the mouth, whose blood contained 3,312,500 red globules per c. mm. If the blood of a person in such a condition contained more than 3,000,000 cells to the c. mm., the number of 4,000,000 is certainly too low a standard for health. In the same lecture M. Hayem remarks that he has never, even in extreme anæmia, found less than 3,000,000 cells per millimetre, although in a foot-note he adds that since the lecture was delivered his assistant, M. Dupérié, had found in two hospital patients in his service "a number of globules somewhat less than 3,000,000." What, then, are we to think of an examination giving as its result 1,000,000 to the c. mm.? We cannot but regard such a condition of aglobulia as incompatible with life.

The *five last* counts have been placed in a separate series, on account of the manner in which the blood was taken from the finger. All mod-

ern writers upon the subject of blood-cell counting recommend that the finger be so punctured as to cause the blood to flow with the slightest possible pressure. Although not so stated, as far as we are aware, it is supposed that this recommendation is founded upon the presumption that any great amount of pressure would dilute the blood with fluid effused from the smaller veins and squeezed out of the lymph spaces. Writers are accustomed to describe their favorite kind of needle for making the puncture. Following their advice in making the counts above recorded, we punctured our fingers so that the blood generally began to flow spontaneously, and then applied the slight pressure requisite to obtain the amount needed. In the *five last* counts, in order to test the question whether too great stress has not been laid upon this point, the finger was ligatured by winding a cord around it several times, tightly enough to compress the veins, but not to impede the arterial flow; and after it had been *in situ* for one minute, a very slight puncture was made, and forcible pressure applied to the swollen and congested finger pulp. The details of these counts are given below. They were all of B's blood, and their average compared with the average of the same blood obtained in the ordinary way is only a little over 100,000 less, an amount not worth considering. It will also be observed that they are the most even series of counts that we have made, the difference between the lowest, 5,730,000, and the highest, 6,155,000, being 425,000. These two counts were made at an interval of twenty-four hours.

FIRST SERIES WITH GOWERS'S INSTRUMENTS A AND B,

With *Unselected Cover Glasses.*

		1	2	3	4	5	6	7	8	9	10		
B's blood.	Sept. 30, 6.00 P. M.	63	54	55	67	63	61	57	61	73	54	= 6,080,000 per cub. mm.	Instrument B.
	Oct. 1, 6.00 P. M.	57	60	60	42	70	50	52	53	54	44	= 5,420,000 per cub. mm.	Instrument B.
	Oct. 1, 6.00 P. M.	59	49	48	42	52	49	38	50	49	54	= 4,900,000 per cub. mm.	Instrument B.
	Oct. 5, 9.30 A. M.	52	63	56	57	68	68	63	55	51	60	= 5,930,000 per cub. mm.	Instrument B.
	Oct. 7, 10.30 A. M.	51	59	65	50	62	50	56	56	68	63	= 5,800,000 per cub. mm.	Instrument A.
	Oct. 7, 10.30 A. M.	61	71	60	59	59	67	63	61	64	62	= 6,270,000 per cub. mm.	Instrument B.
	Oct. 12, 6.00 P. M.	48	50	66	61	59	54	48	44	50	47	= 5,270,000 per cub. mm.	Instrument A.
	Oct. 14, 5.30 P. M.	61	62	58	57	46	54	47	49	56	69	= 5,590,000 per cub. mm.	Instrument B.
	Oct. 14, 9.30 P. M.	56	63	58	68	61	53	50	57	63	58	= 5,870,000 per cub. mm.	Instrument B.
A's blood.	Oct. 7, 9.00 A. M.	64	60	63	62	64	64	63	71	62	70	= 6,430,000 per cub. mm.	Instrument A.
	Oct. 7, 9.00 A. M.	71	63	77	63	53	68	66	74	79	71	= 6,850,000 per cub. mm.	Instrument A.

Average for B's blood, with both instruments, per cub. mm. = 5,681,111.
Average for B's blood, with Instrument A, per cub. mm. = 5,535,000.
Average for B's blood, with Instrument B, per cub. mm. = 5,722,857.
Average for A's blood, with Instrument A, per cub. mm. = 6,640,000.

SECOND SERIES WITH GOWERS'S INSTRUMENT,

A *Selected Cover Glass* being used with Instrument B, and one *carefully ground* with Instrument A.

		1	2	3	4	5	6	7	8	9	10			
A's blood.	10.15 A. M.	60	61	59	55	57	46	44	59	54	63	Different days.	5,580,000	With Instrument A.
	4.00 P. M.	50	58	62	54	44	43	51	60	51	59		5,320,000	
	9.15 A. M.	48	60	49	50	53	43	57	56	49	59		5,240,000	

		1	2	3	4	5	6	7	8	9	10				
B's blood.	4.00 P. M.	62	64	50	58	53	55	54	62	59	49	Same day.	5,660,000	Instrument A.	Same dilution in both cases.
	4.00 P. M.	48	67	58	67	72	60	64	70	62	67		6,350,000	Instrument B.	
A's blood.	5.00 P. M.	49	55	63	55	51	61	55	55	46	46	Same day.	5,360,000	Instrument A.	
	5.00 P. M.	56	59	58	56	58	70	66	56	76	59		6,140,000	Instrument B.	
A's blood.	10.30 A. M.	59	48	53	58	52	67	50	57	50	57		5,510,000.	Instrument A.	
	3.20 P. M.	48	50	59	50	47	45	52	55	55	58		5,190,000.	Instrument A.	
	10.15 A. M.	55	68	65	61	60	57	52	49	51	45		5,630,000.	Instrument A.	
	10.45 A. M.	59	45	57	64	50	57	53	56	54	55		5,500,000.	Instrument A.	
B's blood.	4.15 P. M.	61	46	54	39	51	50	65	55	47	60	Same day.	5,080,000.	Instrument A.	Same dilution used.
	4.15 P. M.	56	53	65	73	55	67	61	52	58	58		5,980,000.	Instrument B.	
B's blood.	9.30 A. M.	54	58	63	61	65	48	60	46	54	72		5,810,000.	Instrument B.	
B's blood.	9.45 A. M.	63	54	65	49	60	61	59	60	63	54		5,880,000.	Instrument B.	
A's blood.	6.00 P. M.	56	46	38	45	53	36	58	59	49	46		4,860,000.	Instrument A.	After loss of night's rest and prolonged physical exercise with little food.
B's blood.	10.30 A. M.	55	53	52	63	64	70	57	63	64	63		6,040,000.	Instrument B.	
B's blood.	10.45 A. M.	59	57	50	50	61	65	54	65	56	48		5,650,000.	Instrument B.	
B's blood.	10.15 A. M.	70	69	63	59	54	63	54	53	69	59		6,130,000.	Instrument B.	
B's blood.	8.00 P. M.	65	65	58	64	63	60	76	62	63	62		6,380,000.	Instrument B.	
B's blood.	8.00 P. M.	73	61	63	60	54	56	64	58	57	51		5,970,000.	Instrument B.	
B's blood.	4.45 P. M.	61	58	73	67	71	62	73	72	69	66		6,720,000.	Instrument B.	
B's blood.	10.15 A. M.	51	54	56	44	46	50	52	42	61	60		5,160,000.	Instrument B.	
B's blood.	11.15 A. M.	49	39	47	53	52	42	39	49	57	50		4,770,000.	Instrument B.	

Average for A's blood, with both instruments, per cub. mm.	5,433,000.
Average for A's blood, with Instrument A, per cub. mm.	5,354,444.
One count of A's blood, with Instrument B, per cub. mm.	6,140,000.
Average for B's blood, with both instruments, per cub. mm.	5,827,142.
Average for B's blood, with Instrument A, per cub. mm.	5,370,000.
Average for B's blood, with Instrument B, per cub. mm,	5,903,333.

Percentage variation of the two instruments on first trial,	11.4.
Percentage variation of the two instruments on second trial,	13.8.
Percentage variation of the two instruments on third trial,	15.6.
Percentage variation of the two instruments on fourth trial,	18.
Average percentage variation of the two instruments	14.7

NACHET'S INSTRUMENT WITH SELECTED, OR GROUND, COVER GLASS.

Nov. 3, 5.30 P. M. A's blood.	12	15	18	13	19	17	15	12	17	19	12	13	16	11	16	13	238	Average per c. mm. 6,080,000.
	9	18	11	14	12	16	14	15	17	14	17	15	20	11	13	18	234	
	11	12	17	15	16	12	17	15	16	17	11	14	14	13	15	14	262	
	18	18	18	19	14	21	23	14	18	16	23	11	12	12	17	16	262	
	16	14	18	12	15	19	15	13	15	18	14	16	17	17	17	17	253	
Nov. 5, 10.30 A. M. A's blood.	17	17	14	18	15	21	15	15	18	13	12	10	16	18	20	14	242	Average per c. mm. 6,370,000,
	24	14	11	20	16	16	12	17	12	17	16	19	19	14	15	14	243	
	18	16	16	16	16	17	20	14	16	19	16	19	15	19	20	16	256	
	16	21	11	15	17	21	15	17	13	16	11	17	14	14	14	14	272	
	18	15	13	16	15	15	15	18	20	13	14	12	21	13	20	19	257	
Nov. 5. 3.10 P. M. A's blood.	18	16	12	15	14	16	11	15	12	16	16	14	12	12	12	18	229	Average per c. mm. 5,720,000.
	16	16	11	17	15	14	14	14	15	14	14	9	13	14	11	15	222	
	11	9	15	20	13	16	13	13	15	11	12	11	18	7	10	12	206	
	16	15	16	11	15	15	12	14	21	11	18	13	17	20	16	19	249	
	20	15	16	17	15	11	15	16	10	16	15	19	16	10	13	14	238	
Nov. 5, 5.30 P. M. B's blood.	15	13	13	18	14	15	18	16	15	15	19	16	23	16	12	14	252	Average per c. mm. 6,285,000.
	16	16	20	11	13	16	19	17	22	17	14	20	20	21	17	19	278	
	12	18	19	14	17	16	10	19	16	17	17	15	14	13	13	19	249	
	17	13	17	18	13	21	14	16	12	16	13	14	12	15	18	14	243	
	16	13	16	16	14	12	21	12	22	11	13	13	15	13	13	15	235	
Nov. 5, 6 P. M. B's blood.	14	14	14	21	15	11	12	16	10	11	10	10	15	13	13	19	218	Average per c. mm. 6,145,000. A trace of blood remained in pipette, making it hardly a fair count.
	15	15	7	10	15	14	14	11	15	8	16	13	13	15	25	12	228	
	16	17	13	13	11	16	11	16	14	12	16	15	14	9	15	12	220	
	19	12	20	14	14	7	14	18	12	14	13	18	11	8	18	13	225	
	18	15	22	13	12	18	17	12	12	15	12	18	13	12	15	14	238	
Nov. 6, 4.45 P. M. B's blood.	12	12	12	10	12	18	13	19	16	7	16	16	16	13	14	14	220	Average per c. mm. 5,450,000.
	16	11	16	10	16	16	15	12	14	15	18	8	12	14	13	15	221	
	13	18	14	13	11	13	14	10	15	15	9	21	13	13	8	16	216	
	13	11	12	15	14	14	13	19	14	17	10	9	9	14	11	17	212	
	12	12	13	13	11	15	17	14	20	11	14	16	12	18	9	14	221	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
Nov. 6, 5.15 P. M. A's blood.	12	12	16	15	15	15	12	18	12	16	12	14	16	11	17	13	226	Average per c. mm. 5,620,000.
	10	11	19	9	14	12	11	16	10	12	15	14	12	14	14	8	201	
	14	18	18	13	14	10	18	16	16	14	11	16	14	16	12	15	235	
	14	17	15	15	15	17	16	15	9	14	12	12	14	12	10	18	225	
	12	14	21	12	20	15	15	18	13	11	20	19	13	12	16	10	241	
Nov. 4, 10.30 A. M. B's blood.	18	17	16	14	15	18	20	16	17	17	21	22	16	17	18	17	279	Average per c. mm. 6,190,000.
	17	15	10	16	13	16	17	13	15	12	6	16	16	13	12	15	222	
	12	22	21	15	12	13	14	12	15	16	16	21	16	15	15	12	247	
	21	15	14	16	17	12	18	17	19	17	25	12	15	13	15	19	267	
	14	12	19	21	12	15	14	10	18	13	17	17	18	12	12	9	233	
Nov. 4, 5.30 P. M. B's blood.	21	17	11	24	20	16	14	15	14	13	14	13	17	13	13	15	250	Average per c. mm. 5,865,000.
	16	16	12	14	11	13	16	16	14	21	11	13	16	16	10	9	224	
	18	18	16	18	19	16	21	14	17	11	14	11	13	13	15	18	252	
	17	19	12	14	19	18	12	15	15	18	22	20	12	11	5	12	241	
	Details of fifth square missing, but result recorded.																206	
Nov. 6, 5.30 P. M. A's blood.	22	12	16	15	15	15	12	18	12	16	12	14	16	11	17	13	236	Average per c. mm. 5,690,000.
	10	11	19	9	14	12	11	16	10	12	15	14	12	14	14	8	201	
	14	18	18	13	14	10	18	16	16	14	11	16	14	16	12	15	235	
	14	17	15	15	15	17	16	15	9	14	12	12	14	12	10	18	225	
	12	14	21	12	20	15	15	18	13	11	20	19	13	12	16	10	241	
Nov. 7, 11.30 A. M. B's blood.	18	20	19	15	18	14	10	21	16	16	24	18	11	18	11	16	265	Average per c. mm. 6,195,000.
	17	20	17	19	9	15	16	21	16	16	16	11	18	14	10	21	256	
	12	14	18	17	19	20	24	16	14	12	12	18	22	14	17	14	263	
	14	14	16	10	8	7	13	21	17	11	13	9	16	11	16	14	210	
	14	13	15	14	17	15	13	24	20	7	12	13	20	17	12	19	245	
Nov. 7, 4.30 P. M. A's blood.	14	16	13	13	16	18	12	17	15	16	12	12	11	19	13	15	232	Average per c. mm. 5,340,000.
	18	15	10	16	10	18	12	15	14	13	13	9	11	17	13	14	218	
	13	9	17	16	12	9	15	10	12	11	16	13	13	13	10	10	199	
	14	15	16	11	13	12	15	14	13	12	14	14	15	16	10	11	215	
	15	17	16	11	9	9	14	13	14	12	12	15	11	14	11	11	204	
Nov. 7, 5.30 P. M. A's blood.	16	13	14	17	24	18	18	20	16	18	16	13	14	15	13	20	265	Average per c. mm. 6,130,000.
	15	17	21	16	10	20	20	19	14	12	16	16	13	17	22	14	262	
	17	11	21	23	18	13	12	14	12	17	9	12	13	15	17	12	235	
	15	16	23	14	19	14	16	14	14	10	13	8	18	10	10	13	227	
	13	10	14	18	10	16	17	18	14	18	16	16	15	11	14	17	237	
Nov. 8, 10.45 A. M. A's blood.	15	15	16	18	12	7	17	9	10	9	17	17	9	19	10	8	208	Average per c. mm. 5,780,000.
	18	19	18	13	14	15	12	14	11	12	17	15	14	14	13	12	231	
	14	15	14	17	16	11	16	11	11	12	13	18	16	15	16	14	229	
	15	17	11	15	16	15	11	19	11	15	14	16	18	16	19	12	240	
	18	11	15	15	18	14	18	15	18	12	21	14	20	11	13	15	248	
Nov. 12, 12 M. B's blood.	11	19	14	20	11	17	14	17	11	17	18	13	18	12	8	20	240	Average per c. mm. 5,640,000.
	17	11	17	16	11	13	17	13	16	15	15	15	12	13	20	12	233	
	9	13	16	12	14	14	11	12	14	10	14	15	17	14	12	17	214	
	23	15	16	14	10	18	14	13	12	18	15	16	8	10	13	14	229	
	16	15	14	13	18	14	10	12	12	14	12	10	14	12	13	13	212	
Nov. 12, 1 P. M. A's blood.	16	12	7	17	16	16	11	16	6	16	11	16	10	10	16	11	207	Average per c. mm. 5,195,000.
	14	12	11	10	12	17	15	10	18	13	17	13	12	13	10	15	212	
	13	13	11	15	15	8	7	13	11	11	17	14	14	13	9	12	196	
	15	14	11	13	16	15	13	15	9	10	14	8	12	10	9	14	198	
	18	15	15	16	13	15	14	9	11	11	16	13	13	14	18	15	226	
Nov. 13, A's blood. Time not recorded.	10	12	18	7	11	14	13	16	13	12	12	8	11	10	8	10	185	Average per c. mm. 5,100,000.
	13	14	13	18	13	11	13	10	7	11	16	16	12	13	5	13	198	
	12	10	13	13	11	7	15	10	20	15	12	10	15	15	9	15	202	
	16	13	15	18	12	14	16	11	13	14	14	15	15	10	14	9	219	
	12	10	15	11	14	16	14	14	15	10	14	15	15	17	13	11	216	
A's blood.	14	16	17	12	17	9	12	17	13	13	9	8	21	12	7	12	209	Average per c. mm. 5,670,000.
	14	13	14	20	18	12	13	17	11	13	15	8	18	10	18	12	226	
	10	13	13	14	15	12	16	14	14	20	17	15	15	19	13	12	232	
	13	19	14	19	13	16	19	17	18	12	18	17	16	11	16	12	250	
	14	17	12	14	12	14	18	15	16	12	8	16	11	11	14	13	217	
Nov. 14, 11.45 A. M. B's blood.	16	14	10	17	17	13	11	16	15	12	15	11	15	10	13	9	214	Average per c. mm. 5,525,000.
	18	15	13	11	11	11	12	13	20	19	16	13	17	15	14	14	232	
	16	16	15	13	7	14	15	13	14	19	11	12	9	19	9	12	214	
	13	16	8	16	11	17	11	15	12	17	14	10	21	19	7	18	225	
	14	18	14	17	12	11	14	16	8	17	12	13	13	16	9	16	220	
Nov. 15, 11 A. M. B's blood.	18	18	12	13	15	19	19	18	20	20	14	17	12	12	15	11	253	Average per c. mm. 6,140,000.
	18	15	12	10	18	10	18	14	12	15	16	16	15	8	15	18	230	
	13	20	18	15	16	20	21	15	14	21	15	8	8	14	12	10	240	
	16	20	14	18	18	20	18	11	19	18	17	15	18	19	13	23	277	
	15	9	14	18	13	18	11	16	14	14	12	21	12	16	11	14	228	
Dec. 18, 10 A. M. B's blood.	13	13	18	12	14	21	21	11	12	20	16	13	13	14	16	10	237	Average per c. mm. 6,550,000.
	14	18	16	14	21	23	17	15	20	19	12	23	10	17	15	19	273	
	16	17	21	17	21	18	26	15	19	12	16	21	15	15	21	13	283	
	14	10	20	15	16	17	13	16	14	19	11	15	14	15	16	16	241	
	17	15	18	17	10	20	19	18	16	21	15	19	20	15	15	21	276	
Dec. 18, 11.15 A. M. B's blood.	21	16	19	14	18	14	18	14	12	13	13	18	21	16	21	18	266	Average per c. mm. 6,370,000. For two weeks previous to last two counts, had been taking protochloride of iron pills.
	20	15	18	15	10	23	23	15	21	17	14	14	18	17	15	17	272	
	21	19	11	17	16	15	15	14	20	18	17	12	21	14	17	16	263	
	14	19	20	18	16	16	17	11	14	16	14	19	18	13	16	13	244	
	11	18	12	15	7	18	14	12	13	19	16	15	13	17	14	15	229	
Dec. 26, 4.50 P. M. B's blood.	16	20	18	14	12	17	13	19	13	19	14	12	20	14	14	16	251	Average per c. mm. 6,180,000.
	14	18	19	14	19	14	24	15	14	12	11	19	15	13	12	16	249	
	17	12	20	14	11	15	14	16	8	16	19	18	15	15	23	12	245	
	14	14	19	16	19	14	19	15	17	16	12	14	12	14	13	19	247	
	17	13	17	22	15	13	13	16	20	16	14	17	13	10	11	17	244	

Average for A's blood (11 counts) per cubic mm. . . . . 5,699,545.

Average for B's blood (12 counts) per cubic mm. . . . . 6,044,583.

SERIES OF COUNTS OF BLOOD OBTAINED WITH EXTREME PRESSURE.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
	11	13	17	15	19	11	16	19	21	22	20	20	16	16	17	18	271	
Dec. 26,	12	18	14	9	15	13	16	14	13	12	11	15	16	18	17	10	223	
5.10 P. M.	14	15	8	16	15	18	8	8	15	14	9	13	16	18	12	16	215	Average per c. mm 5,895,000
B's blood.	19	12	12	14	13	8	10	11	11	17	16	14	13	8	15	12	205	
	20	21	17	13	12	20	21	13	15	12	18	17	20	13	20	13	265	
	14	18	13	14	15	16	12	17	15	14	17	16	20	11	11	17	240	
Jan. 2d,	13	19	16	14	15	15	16	9	11	16	17	14	16	10	16	12	229	
5.10 P. M.	17	12	17	13	14	16	19	15	18	17	14	14	16	16	15	17	250	Average per c. mm. 6,020,000
B's blood.	16	16	15	21	14	19	15	18	19	12	14	13	11	6	16	17	240	
	15	15	16	13	12	19	18	16	22	9	16	22	12	18	12	10	245	
	19	15	17	17	18	22	21	15	17	13	14	16	12	18	15	13	262	
Jan. 6,	18	18	16	15	15	10	15	14	14	12	16	19	9	18	20	11	240	
A. M.	14	15	18	16	10	12	19	16	23	19	18	22	16	17	14	10	259	Average per c. mm. 6,155,000
B's blood.	16	16	14	13	14	13	18	14	16	11	17	14	20	13	14	18	241	
	16	15	15	17	13	14	13	11	15	14	19	14	13	12	13	15	229	
	15	18	12	17	12	17	14	19	13	11	15	10	16	8	23	11	231	
Jan. 6,	16	9	11	15	17	15	22	16	13	18	19	8	14	15	16	15	239	
8.30 P. M.	22	19	12	15	11	16	9	11	9	20	20	9	16	17	17	13	236	Average per c. mm. 5,905,000.
B's blood.	13	14	17	15	10	12	22	14	17	21	12	16	20	12	14	21	250	
	16	15	13	20	13	15	18	11	11	14	15	11	14	17	11	11	225	
	17	13	12	18	14	18	13	13	9	16	18	9	15	11	14	18	228	
Jan. 7,	13	15	13	15	18	15	7	23	11	19	15	11	8	19	16	16	234	
8 P. M.	14	13	15	11	13	13	11	19	15	17	11	17	15	11	12	13	220	Average per c. mm. 5,730,000
B's blood.	22	16	18	17	8	16	13	14	16	15	16	15	15	16	13	11	241	
	10	14	14	9	12	14	11	18	16	14	15	17	18	15	16	10	223	

Average of the above five counts per c. mm. 5,941,000

In the preceding tables we have given the counts in full, in order that those interested in this subject may be able to judge of the widely varying details upon which the averages are founded. In no other way can the clinical value of blood-cell counting be fairly estimated in its application to individual cases, and it is this application alone in which the general medical profession is interested. We would particularly emphasize our opinion that a mere statement of results, to the exclusion of details, is calculated to mislead. In the first Gowers series of counts, those made with unselected cover glass, there are recorded two counts of A's blood, with instrument A, giving an average of 6,640,000 per c. mm. Exception may possibly be taken to this large average as due to inaccurate measurements, although we have every reason to believe the measurements correct, and are inclined to adduce this result as an additional proof of the great importance of a well-selected cover glass, for in all subsequent counts the average of A's blood was inferior to that of B.

In the counts made by Hayem and Nachet's method, the measurements were made with the pipettes belonging to Gowers's instrument, and as these are of different dimensions from those that usually accompany the instrument of Hayem and Nachet, giving a more concentrated mixture of cells, a different calculation had of course also to be used. We follow Keyes's statement of the calculation as far as concerns the factors of the cell and eye-piece: "The glass cell on the slide is $\frac{1}{5}$ mm. deep. The eye-piece micrometer marks off $\frac{1}{5}$ mm. square; therefore the count of corpuscles must indicate the number contained (in the dilution used) in $\frac{1}{5}$ mm. cube. But $\frac{1}{5}$ mm. cube is $\frac{1}{125}$ of a c. mm.; therefore the number counted must be multiplied by 125." The blood was diluted by adding 199 parts of fluid to 1 of blood (5 c. mm. to 995

c. mm.); therefore the product above obtained must be again multiplied by 200 to get the number of cells in a c. mm. of pure blood, but instead of multiplying twice, a single multiplication of 125×200, 25,000, will give the same result. This is a much easier calculation than the one necessitated by the pipettes that ordinarily accompany the instrument of Hayem and Nachet. Our Hayem and Nachet cell was made by Mr. Zentmayer, and the eye-piece ruled by the same well-known instrument maker. The Gowers instruments were made by Mr. Hawksley, 300 Oxford St., London. The fluid used to dilute the blood was Keyes's borax solution, and was found to answer admirably.

We cannot perceive any advantage in Gowers's instrument over that of Hayem and Nachet beyond the facility it affords for reckoning percentages, and this, we think, is more than counterbalanced by the superior ease with which counts are made in the smaller squares of Hayem and Nachet. One is enabled, by the latter instrument, to count a greater number of squares with less fatigue in the same time, and the importance of counting a great number of corpuscles has been sufficiently dwelt upon. Although Dr. Gowers claims that his instrument can be used to reckon the percentage of white corpuscles as well as that of the red, our experience inclines us to agree with Dr. Jos. G. Richardson [1] that the tendency of the white cells to adhere to the inner surface of capillary tubes will "lead to incorrect estimates of the proportion" existing between them and the red.

In conclusion we would reply to a question that will arise in the minds of all readers of this paper: "Can accuracy be reached with the present blood-cell counting instruments?" Our answer is: "Yes, but through an amount of labor of which, so far, we have seen no detailed account."

[1] New York Medical Record, March 2, 1878.